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# Kinetics of colour changes in marigold petals during microwave drying

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■ **ABSTRACT :** Microwave assisted convective dehydration of marigold species *Pusa Narangi* petals was carried out at three levels each of microwave power (140, 210 and 280 W), air temperature (30, 45 and 60°C) and a constant air velocity of 0.5 m/s. The experiment was laid out using full factorial CRD with three replications. The colour values L, a, b of the marigold petals was measured with Hunter Lab colourimeter which were found decreasing. There was change in chroma values of marigold is due to drying by using both combinations of microwave power level and temperature. The total colour change has been increased significantly during microwave drying with drying time.

■ **KEY WORDS :** Marigold, Colour, Hunter lab colourimeter, Chroma

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Marigold (*Tagetes erecta* L.; Family-*Asteraceae*) is an herb of ancient medicinal repute, native to Mexico. It has long been used as a food and as an ingredient in animal feed (Duhan *et al*., 2016a). Marigold flowers are used as tea, food colourant and ingredient in cooking. They may be used as the fresh petals or as a dried powder. Marigold has a very short shelf-life and is prone to microbial degradation. Therefore, it's drying and preservation is very important for commercial usage. Drying is one of the oldest and most important thermal processing techniques aimed at reducing water activity, inactivate enzymes and restrain deteriorative microbial growth (Lijuan *et al*., 2005). However, traditional drying techniques impart an adverse effect on quality and organoleptic properties of products mainly because of physio-chemical changes occurring in the tissue during drying. The method used for drying affects properties such as colour, texture, density, porosity and absorption characteristics of materials (Yang and Atallah, 2006). The most common methods used for drying are natural drying (drying in the shade or sun drying) and hot air drying. But these methods have some disadvantages such as the natural drying has contamination problems especially in rainy season, longer drying times due to low energy yield, and inability to handle the large quantities to achieve consistent quality standards (Gunawan and Barringer, 2000). In addition, hot air drying has low-energy efficiency and a lengthy drying time during the last stage of drying. These situations deter food industry for adoption of these methods. Microwave is an innovative technique of food drying that provides volumetric heating means heating of all sides (Kumar *et al*., 2015). Therefore, compared with natural and hot air drying; microwave convective drying is an alternative method due to availability of uniform energy to the inner sides of the material, space utilization, hygienic conditions, energy saving, and fast start up and shutdown conditions.

Colour of an object is one of the most important quality factors and plays a significant role in appearance, processing, and consumer acceptability of agricultural materials. colour is an important attribute in food acceptance (Santos *et al*., 2013). The colour measurements of flower can be used as an indirect way to determine the change in quality, since they are simpler and faster than chemical analysis. Hunter colour parameters (L, whiteness/darkness; a, redness/ greenness; and b, yellowness/blueness) have previously proved valuable in describing visual colour deterioration and providing useful information for quality control in fruits and vegetables (Maskan *et al*., 2002). There are other parameters derived from the Hunter L, a, and b scale: the total colour change (ΔE); chroma, which indicates colour saturation and is proportional to its intensity. Browning index (BI) represents the purity of brown colour and is reported as an important parameter in drying processes where enzymatic and non-enzymatic browning takes place (Maskan, 2000).

Though a number of studies on the kinetics of colour change in vegetables have been reported but no such study on marigold petals has been found in the literature. Therefore, the purpose of this work is to study the kinetics of colour degradation by using three Hunter parameters lightness (L), redness (a), and yellowness (b) during microwave drying of marigold at four power levels.

## METHODOLOGY

### Plant material :

*Pusa narangi*, a variety of African marigold (*T. erecta* L.) flowers obtained from Directorate of Floriculture, Indian Agricultural Research Institute, New Delhi. Flowers were harvested till full bloom stage and petals were cut.

### Drying equipment and procedure :

Fresh marigold flower petals 25 g each were subjected to Microwave assisted convective drying (MACD) at 140 W, 210 W and 280 W when the temperature was fixed to 60°C and 30° C, 45° C and 60° C when the power level was fixed to 210 W on the basis of optimum conditions obtained in previous experiment (210 W, 60° C, 0.5 m/s) in a modified domestic oven (Swain *et al*., 2012 and Duhan *et al*., 2016b). Air flow was kept constant in both the experiments at 0.5 m/s. Drying experiments were performed in a laboratory scale microwave-convective dryer (consists of 4 subsystems: air supply unit, heating unit, drying unit, and control unit) available in the Division of Food Science and Post Harvest Technology, Indian Agricultural Research Institute, New Delhi. The blower (0.24 HP, 50 Hz, continuous single phase) blows the air in to the heating section, where the temperature was regulated by thermostat before entering the microwave oven. The thermostat (MDC2901; Multispan Instruments, Ahmedabad, India) was mounted over the blower to adjust the air temperature, which can be operated manually using the regulator unit. The microwave oven (WP700L17.3 MW Oven, 17-L capacity; LG Electronics Ltd., Changwon, Korea) with technical features of about 230 V, 50 Hz, and 700 W with a frequency of 2,450 MHz has dimensions of 295, 458, and 370 mm and consisted of a 270 mm diameter turn table at the base of the oven and it also operates in pulsed mode. The adjustment of microwave power level and processing time is done with an analogue controller. Air velocity was measured using a hot wire anemometer (least count of 0.1 m/s; model no. M-4204; LT Lutron, Taipei, Taiwan). Three replications of each experiment were performed according to preset conditions.

### Colour measurements :

During microwave assisted convective drying, marigold petal samples were removed from the microwave oven periodically for colour measurements and their colour (L, a, b) was measured with a Hunter Lab colourimeter. The total colour change (ΔE) Eq. (1) and chroma Eq. (2) were calculated from the Hunter L, a, b scale and used to describe the colour change during drying

$$\Delta E = \sqrt{(L_0 - L_t)^2 + (a_0 - a_t)^2 + (b_0 - b_t)^2} \qquad (1)$$

where, $L_0$, $a_0$, $b_0$ are the initial colour measurements of raw marigold petal samples and $L_t$, $a_t$, $b_t$ are the colour measurements at pre-specified time

$$\text{Chroma} = \left[a_t^2 + b_t^2\right]^{0.5} \qquad (2)$$

### Experimental designs and statistical analysis :

A full factorial CRD was adopted with three power levels (140, 210 and 280 W) and three air temperature (30, 45 and 60 °C) and at a constant air velocity of 0.5

m/s using three replications. The data was analyzed using SAS software SPSS (1998).

## RESULTS AND DISCUSSION

To study the combined effect of hot air at 60$^0$C and three level of microwave output powers, 140, 210 and 280 W and combined effect of 210 W microwave power with three level of hot air *viz.*, at 30$^0$, 45$^0$ and 60$^0$C on colour change of marigold petals for drying.

### L values :

Fig. 1 showed L value decreased from 54.93 to 35.44, 54.94 to 35.45, and 54.94 to 33.29 with the drying time when the temperature of hot air was at 60$^0$C and microwave output powers increases from 140 to 210 and 280 W, respectively. The effect of microwave power at 210 W and hot air with increasing temperature from 30$^0$C to 45$^0$C and 60$^0$C on L-value were also found decreasing from 55.48 to 35.98, 55.55 to 36.13 and 55.94 to 35.55, respectively which is shown in Fig. 2

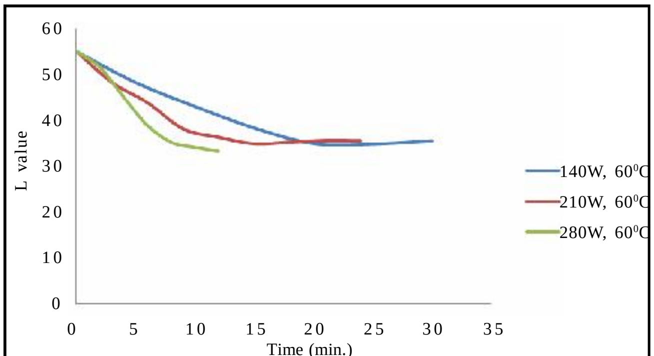


**Fig. 1 : Change of L value as a function of drying time at various microwave output powers when temperature was constant**

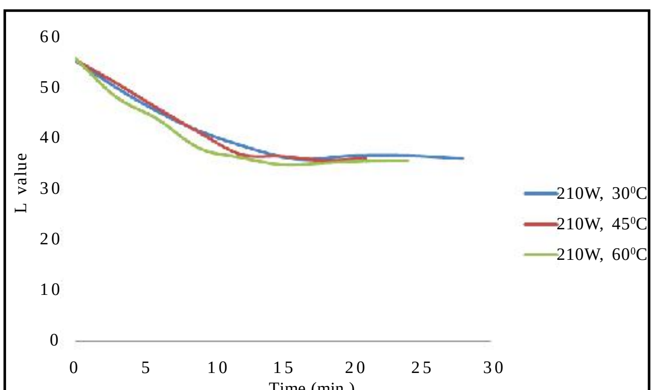


**Fig. 2 : Change of L value as a function of drying time at various air temperatures when power was fixed**

Consequently, it has been found that the degradation of L-value for constant microwave power *i.e.* 210W and increasing temperature *i.e.* 30$^0$C, 45$^0$C and 60$^0$C, was found less than combination of hot air at 60$^0$C and different microwave power level varies from 140 to 210 and 280 W. It has been stated that the variation in the brightness of dried samples can be taken as a measurement of browning (Ibarz *et al*., 1999).

### a values :

The initial positive *a* value of colour for the marigold samples were found 34.97, indicating redness of samples. For redness/greenness scale, the final *values* varied from 25.2 to 26.32 for combination of hot air (at 60$^0$C) and different microwave output power (Fig. 3) while for the combination of 210 W microwave power and different temperature, it was varied from 24.82 to 26.32 (Fig. 4). So, it can be concluded that all the marigold samples have maintained their redness during the drying. a value tells us about the redness of samples which showed a decreasing trend during drying. This may be due to decomposition of carotenoid pigments (Weemaes *et al*., 1999) and formation of brown pigments (Maskan, 2000). Similar observations were also reported by Ibarz *et al*. (1999).

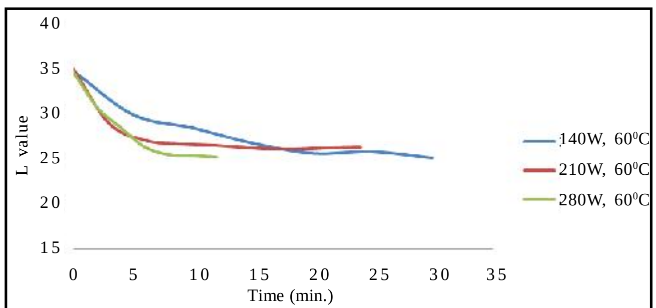


**Fig. 3 : Change of a value as a function of drying time at various microwave output powers when temperature was constant**

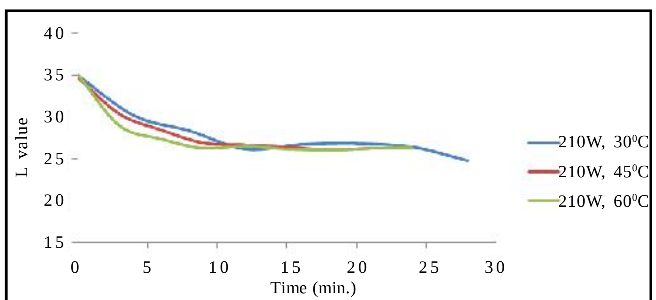


**Fig. 4 : Change of a value as a function of drying time at various air temperatures when power was fixed**

**b values :**

For the yellowness/blueness, the initial b colour values of the samples was found positive (68.89). It showed yellowness of samples. During both drying combination process, the b value of samples were found decreasing.

The initial and final b values varied from 68.89 to 31.99 and 37.37 for hot air at 60$^0$C and as the microwave output power increased (Fig. 5). For the combination of power 210W and different temperature, final b colour values varied from 34.44 to 37.37 (Fig. 6). The loss of *b* value indicates that the yellowness of samples decreased due to application of microwave output powers and hot air. It might be due to decomposition of lutein pigment, non-enzymatic maillard browning and formation of brown pigments.

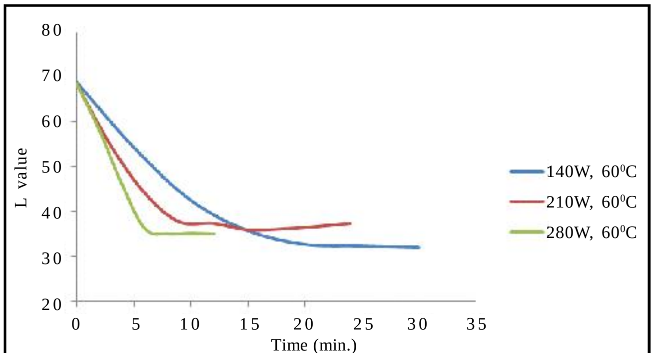


**Fig. 5 :** Change of b value as a function of drying time at various microwave output powers when temperature was constant

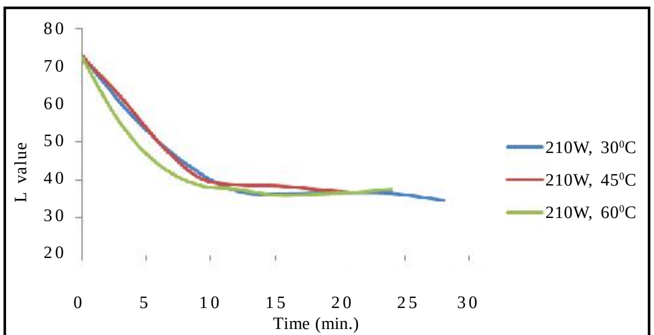


**Fig. 6 :** Change of b value as a function of drying time at various air temperatures when power was fixed

**Total colour change (aE) :**

To evaluate the resultant colour as a whole, the total colour change (ΔE) of marigold petals were analyzed by considering L, a and b values at particular time with respect to its initial values. Consequently it was found that total colour change has been increased significantly during microwave drying with drying time. For hot air at 60$^0$C and variable microwave power, the ΔE ranged between 43.16 to 38.12 (Fig. 7) while for microwave output power 210 W and hot air at 30, 45 and 60$^0$C, it was ranged from 41.61 to 38.12, respectively (Fig. 8). Total colour change signifies the overall visual and qualitative condition of the dried product. Microwave power level, temperature as well as interaction effect between two were found have non-significant effect on the total colour change. There was no significant difference between the total colour change values under all combinations of the parameters. The non-significant difference in the total colour change under all the combinations of independent variables may have been due to the fact that the trigger required to enhance significant colour difference was not reached. It also have been possible that the variation of independent variables was not large enough to induce a significant change in colour values between the considered experimental conditions. The development of

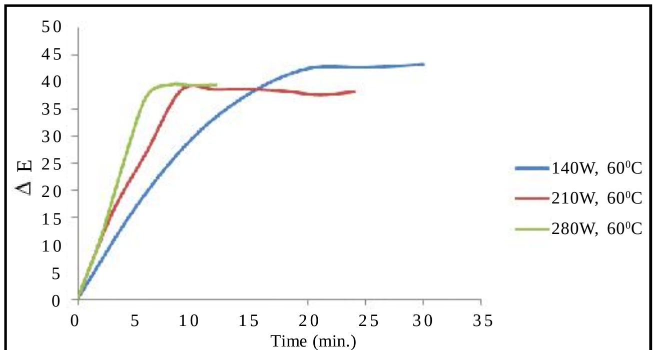


**Fig. 7 :** Change of aE value as a function of drying time at various microwave output powers when temperature was constant

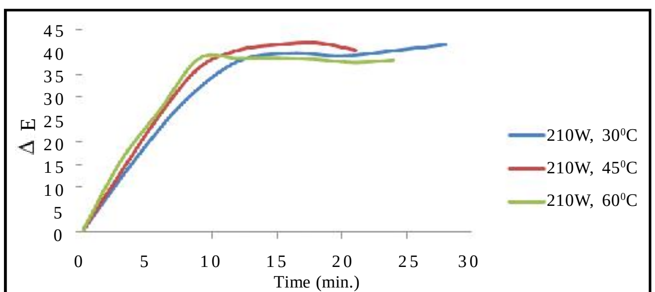


**Fig. 8 :** Change of aE value as a function of drying time at various air temperatures when power was fixed

discolouration of samples during drying may be related to pigment destruction, ascorbic acid browning and non-enzymatic Maillard browning (Ibarz *et al*., 1999 and Duhan *et al*., 2016a).

### Chroma

The change in chroma values of marigold was due to drying by using both above illustrated combinations were found decreasing and closely followed the b values.

The resultant change in chroma values due to drying of the combination of hot air at 60$^0$C and different microwave power was from initial value 76.14 to 40.69 and 45.71 (Fig. 9). On the other hand for 210 W microwave power and varying temperature, it was ranged from 78.09 to 42.45 and 47.03 (Fig. 10). So, it can be concluded from the above result that there was no significant difference in final result of both drying combination. Chroma indicates the stability of yellowness in marigold samples. The change in chroma values of marigold were found decreasing due to decrease in lutein content. In fact Browning is also one of the major contributors for decrease in chroma value.

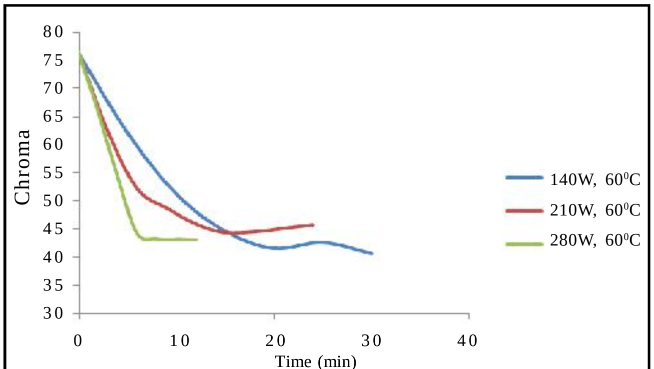


**Fig. 9 : Change of chroma value as a function of drying time at various microwave output powers when temperature was constant**

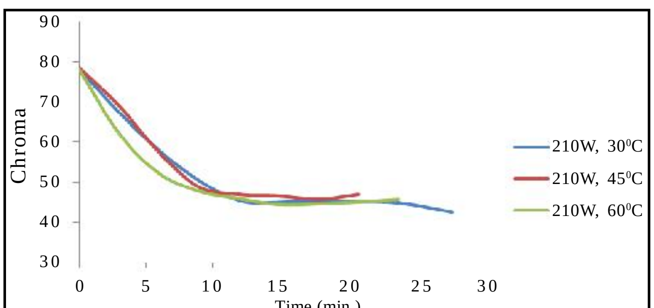


**Fig. 10 : Change of chroma value as a function of drying time at various air temperatures when power was fixed**

### Conclusion :

In both the combinations of microwave power and air temperature L, a and b values was decreased. All the marigold samples have maintained their redness during the drying which was indicated by their a values. The loss of b value indicates that the yellowness of samples decreased due to application of microwave output powers and hot air. It might be due to decomposition of lutein pigment, non-enzymatic maillard browning, and formation of brown pigments. It was also found that total colour change has been increased significantly during microwave drying with drying time. The change in chroma values of marigold were found decreasing and closely followed the b values due to decrease in lutein content.

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